Seismic devices

Infrastructure | Buildings | Industrial structures

mageba expansion joints with seismic protection features

Fuse Systems for TENSA®MODULAR

effective, safe, reliable

mageba

Overview and general requirements

Main application

In seismic regions, it is vital that bridges and their expansion joints continue to carry traffic after an earthquake.

In particular, modular joints that are by design capable of accommodating large movements can be fitted with a Fuse-System. This subtle seismic feature is designed to fail in a controlled manner, thus further increasing the joint's ability to accommodate extreme closing movements.

After a seismic event, the joint continues to function and does not need to be replaced.

Seismic protection of structures

The use of seismic protection systems not only **improves the safety** of structures in the event of an earthquake, but also enables the design of **sleeker and more economical** structures, considering the whole life cycle cost.

The use of seismic protection systems in bridges ensure the proper functioning of the structure during all service conditions due to effects caused by temperature, wind, braking forces, impacts, etc. In case of an earthquake, the protection system will ensure the safety of the structure, by avoiding severe damages to structural elements.

TENSA®MODULAR expansion joint

The application of mageba's proven modular expansion joints TENSA®MODULAR are typically used in bridges with movements of over 80 mm and can extend well over 2,400 mm. The movement gap at the end of a bridge deck is divided into smaller individual gaps by horizontal center beams which allow movements and rotations in all 3 directions.

More details about the TENSA®MODULAR expansion joint can be found in the product brochure on our website **mageba-group.com** or simply by scanning the QR code below.

Joint safety – seismic safety features

For bridges in seismically active regions, it is vitally important that their expansion joints continue to allow traffic after an earthquake, as bridges play a crucial role in providing access to remote locations, especially after natural disasters such as earthquakes.

Besides typical solutions for seismic protection systems related to "strengthening" and "mitigation" strategies, mageba has also further developed its modular expansion joints by adding specific features that provide safety in case of a seismic event.

Solutions for modular joints

Since the expansion joints of large bridges are typically concreted or welded to the bridge's superstructure, any exceeding of their movement capacity during an earthquake is likely to cause great damage to the joint and the connecting superstructure.

By adding a seismic safety feature such as a Fuse-Element or a Fuse-Box to a modular joint, **the full serviceability** of the structure after an earthquake can be assured. This allows the crossing of emergency services, which becomes essential to ensure the safety of the population, especially for bridges and hospitals.

The use of either a Fuse-Element or a Fuse-Box system offers various application possibilities.

Solution 1: Fuse-Element

Principle

The general idea of both systems, the Fuse-Element and the Fuse-Box, is to create additional closing movement by uplift movement. Rather than designing the expansion joint with enough movement capacity to facilitate even the largest potential earthquake, it may be far more economical to introduce a Fuse-System into its design, which will fail in a controlled manner when normal service movements are exceeded.

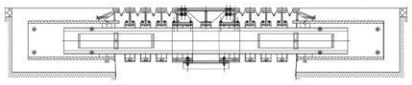
The Fuse-Element seismic design feature of a TENSA®MODULAR expansion joint is based on the principle of incorporating a trapezoid steel element in the driving surface of the joint located between the joint's center beams and/or edge profiles.

This element rigidly bridges two parts of the joint's driving surface in normal service. However, in case of an earthquake, it is forced upwards and out of the joint's surface to the extent required for the joint to accommodate extreme closing movements.

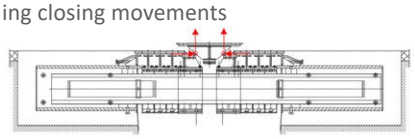
In this case it is not the expansion joint's connection to the bridge superstructure that fails in a controlled way, but the connections of the specially designed Fuse-Element to the joint – thus impact to the expansion joint and the connecting superstructure can be essentially reduced.

Functionality

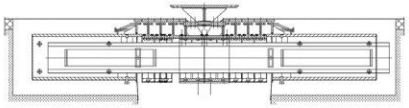
Fuse-Element in neutral/central position



Fuse-Element is lifted upwards by exceeding closing movements



Fuse-Element at max. uplift position and min. possible closing position



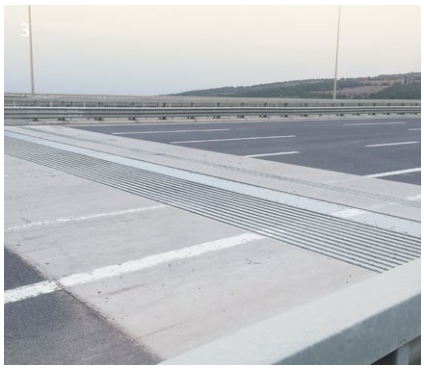
Key benefits

+ Increasing the safety of the structure and its users
+ Full degree of freedom (including all rotations) is achieved by separating the Fuse-Element from the edge profile
+ The number of Fuse-Elements can be increased as required
+ The whole mechanism is completely integrated in the expansion joint itself
+ No part of the Fuse-Element is in direct contact with the bridge deck
+ Improves the expansion joint's overall durability by effectively splitting it into two smaller joints thus reducing the impact of cumulative friction across the joint
+ All parts are easily accessible for inspection and maintenance, and easily replaceable at all times
+ No replacement of the expansion joints necessary after an earthquake

Application scenario for the Liman Connection Viaduct (Turkey)

Main assumptions for longitudinal movements (13-gap joint):

- **Serviceability Limit State (SLS):** +/- 380 mm
- **Ultimate Limit State (ULS):** +/- 652 mm
- **Earthquake Event (EQ):** +/- 1,055 mm
- Requirements for transversal movements need to be investigated
- Riding quality ensured under normal service conditions (SLS), maximum gap requirement of 80 mm are met
- No damage or repair needed for ULS case
- EQ risk includes rubber seal push out, pop-out of fuse elements by bolt breaking (engineered); fuse is reversible to original position, permitting emergency vehicle to drive over; no damage to bridge structure; minimum repair (bolts, CP touch-up) after EQ needed



1 24-gap modular joint with Fuse-Element installed on the Longjiang Bridge, China. The LR24 modular joint is designed to accommodate service movements of 1,920 mm and required an additional +/- 350 mm of movement capacity in case of an earthquake

2 TENSA®MODULAR expansion joint with Fuse-Element seismic protection feature right after installation on the Liman Connection Viaduct

3 The same 13-gap joint in service featuring a Fuse-Element alongside a smaller 4-gap joint

Solution 2: Fuse-Box

Principle

The mageba Fuse-Box System also protects the TENSA®MODULAR lamella joints and the adjacent structure from earthquake damage. It also often leads to an optimization of the design of the expansion joint with fewer gaps than would otherwise be required in regions prone to earthquakes.

The Fuse-Box does act as a predetermined break point, allowing failure to occur in a controlled, designed manner. In contrast to the Fuse-Element, however, it is directly connected to the bridge structure.

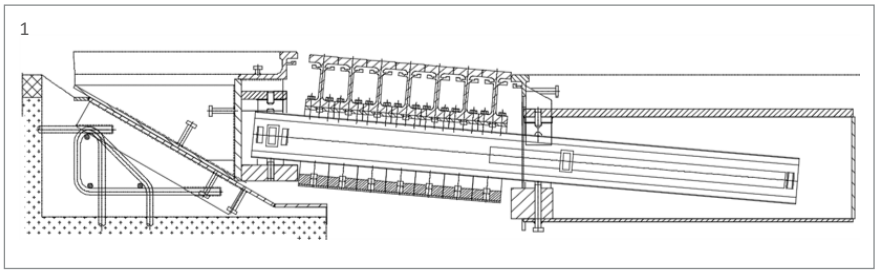
The Fuse-Box, which works as shown in the figures below, consists of a triangular steel nose on one side of the joint, resting on a steel ramp which is concreted or welded to the bridge deck. The connection between the nose and the ramp is designed to fail when the specific movement capacity is exceeded (when the expansion joint has closed fully and the bridge gap closes further). Once this point is exceeded, the nose and the joint to which it is connected can move independently of the ramp and main structure to which the ramp is connected.

During strong earthquake related opening movements, the Fuse-Box also prevents the expansion joint from falling into the bridge gap and thus making it impassable.

The basic idea behind the Fuse-Box System is to protect the bridge deck from high compressive stresses and damage when the bridge structure closes more than there is space in the gaps between the center beams.

Key benefits

+ Increasing the safety of the structure and its users
+ Allows the joint to break out without major damage to the bridge or the joint
+ Additional closing movement by uplift movement
+ Surface of the Fuse-Box hidden below asphalt/concrete
+ No replacement of the expansion joints necessary after an earthquake

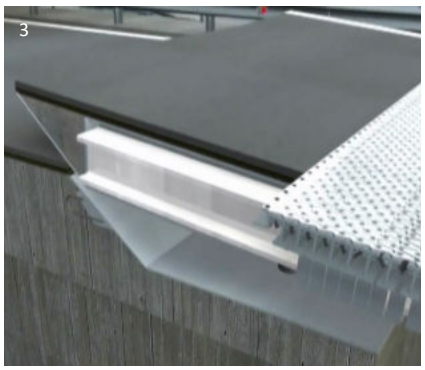


1 Cross-section of a Fuse-Box during an earthquake

2 Illustration of one side of a modular expansion joint with the Fuse-Box design feature under service condition – a steel nose on a steel ramp

3 The joint is closed fully and the bridge movement gap closes further, thus the connection fails enabling the expansion joint to break free at predetermined location, protecting the joint and the bridge superstructure from further damage

4 Huge modular joint during installation with mounted “steel nose” on the Golden Ears bridge, Canada



Fuse-Element vs. Fuse-Box

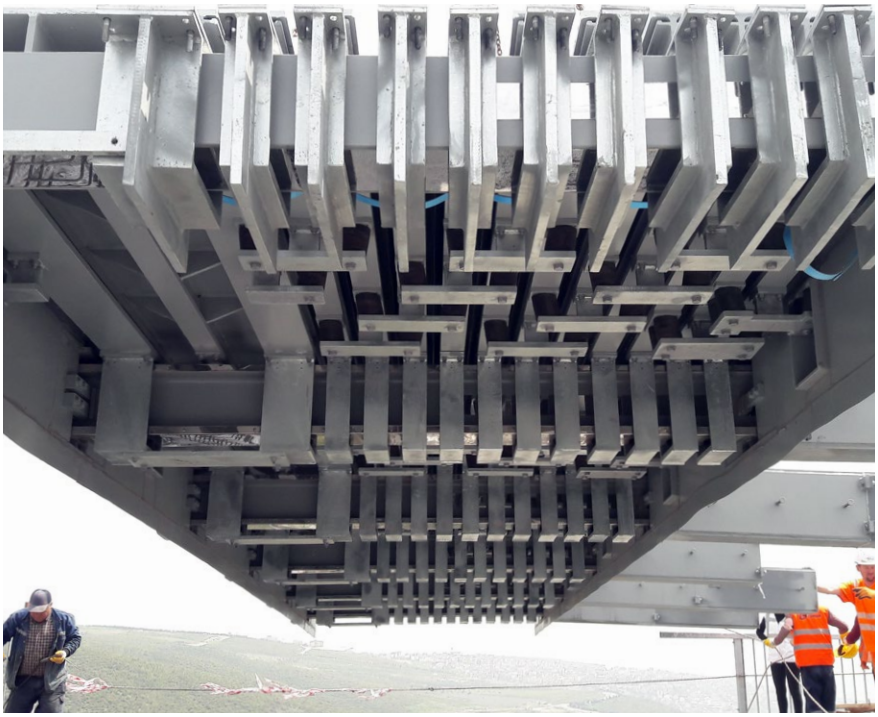
	Fuse-Element	Fuse-Box
Application	Modular joints	Modular joints
Additional closing movement	Min. 250 mm and max. 600 mm per Fuse-Element	300 mm
Seismic safety	■■■■	■■■■
Joint protection	■■■■	■□□□
Maintenance & repair	■■■■	■■□□
Overall complexity	■■■■	■■□□
Number of fuse per joint	1 or more	1
Costs	■■■■	■■■□

Design smarter – not larger

Rather than designing even larger joints by adding further gaps in order to provide the required additional movement capacity in case of an earthquake, the joint is instead equipped with the Fuse-Element.

What a Fuse-Element can do

- Creating additional closing movement for a selected movement case. Typically in a range of min. 250 mm and max. 600 mm per one Fuse-Element
- Generating defined/controlled release forces. Can be selected in min./max. range due to different diameters and distances of the bolts
- Allows high flexibility in pre-setting addressing specific load cases and minimizing maintenance effort



Quality and support

Quality

For six decades, mageba products have proven their worth in thousands of structures under the most demanding conditions. In addition to the product properties, the extensive experience of mageba's well-qualified manufacturing and installation staff also contributes to the high quality and durability of the products.

mageba has a process-orientated quality system that is certified in accordance with ISO 9001. mageba's factories are certified for welding in accordance with ISO 3834-2, and to the current steel construction standard EN 1090.

Testing

If required by the client, full-scale product testing can be carried out. mageba performs the tests in-house as well as with independent 3rd party test institutes. Commonly performed tests are based on European Standard EN 15129:2009 or AASHTO "Guide Specifications for Seismic Isolation Design". Upon request, customized testing based on other codes can also be performed.

Installation

mageba offers supervision of installation for its products all over the world. The supervision is highly recommended to ensure proper installation of the devices and to take benefit of the full mageba guarantee.

Careful handling of the devices is essential during transportation and installation to avoid damages.

Inspection and maintenance

Thanks to the use of high quality components, the application of advanced design methods and a systematic internal quality assurance system, mageba seismic protection devices can be regarded as maintenance free.

Nevertheless, mageba recommends an inspection to be carried out every 5 years to verify the proper functioning of the units.

Upon delivery of the units, mageba submits an installation as well as an inspection and maintenance manual, allowing a regular and appropriate inspection to be carried out by the operation and maintenance staff.

Customer support

Our product specialists will be pleased to advise you in the selection of the optimal solution for your project, and to provide you with a quotation.

On our website **mageba-group.com** you can find further product information, including reference lists and tender documentation.

Project references – Fuse Systems for TENSA®MODULAR


Longjiang Bridge (CN)


Golden Ears Bridge (USA)


Liman Viaduct (TR)


Chilina Bridge (PE)


A9 motorway – Raron (CH)


Val Freghizia Bridge (IT)

mageba seismic protection devices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